

The University of Chicago

THE INFLUENCE OF A CHANGE
OF CONDITIONS UPON THE
AMOUNT RECALLED

A PART OF THE DISSERTATION SUBMITTED TO
THE GRADUATE FACULTY IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF PSYCHOLOGY

By
HELEN JOY REED

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BY HELEN J. REED

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The general purpose of these experiments was to investigate the extent to which the performance of an act is dependent upon the conditions that obtained when that act was learned. The specific problem was to determine the extent to which recall is dependent upon the conditions that prevailed at the time the material was memorized. The general plan of the experiment was to have the subjects memorize under certain specified conditions and to test their ability to recall twenty-four hours later when the same conditions prevailed or when those conditions had been changed in definite, pre-arranged ways. Changes in three typical conditions were arbitrarily selected for study: (1) changes in the sensory situation; specifically, in the kinæsthétic factors, as brought about by alterations in posture at the time of recall; (2) changes in the sensory mode of presenting the stimulus words; and (3) changes in the form of the response at recall.

Most of the experimental literature relates to the first topic, *i.e.*, the relationship of the learned response to the broader sensory situation in which it occurs. Darrow (4) studied the effect of posture on the free association process. He found that certain attitudes tended to facilitate while others inhibited the process insofar as they were congruous or incongruous with the train of thought. Bills (1) experimented with kinæsthétic factors in his study of the influence of muscular tension on the efficiency of mental work. He found that more was accomplished in the periods of muscular tension than during relaxation. The effect of a change of these conditions at the time of recall was not determined, however. Wong and Brown (17) have shown that the more

¹ From the Psychological Laboratory of the University of Chicago.

complicated mental activities required in the solution of the Yerkes Multiple Choice problems are facilitated or inhibited by the condition of the room in which the work is done. Twelve subjects working in an unkept, unattractive attic room made more wrong responses and solved fewer problems than the dozen working in an attractive, artistically arranged study.

Pan (12) made an extensive study of the dependence of learning and recall upon the immediate environmental situation in which the material is presented, the situation in this case referring to the visual context or background in which the material appeared. Pairs of words and words and pictures were to be associated. The context was composed of numbers, words (related or unrelated to the material to be memorized) and picture post cards, on which the paired words were printed. The writer concludes (p. 490) that "the recall of material is favored by the presence of an environmental factor which has some associative connection with that material and in the absence of such an association the environmental situation is likely to be unfavorable to recall." Oberschelp (11) studied the influence of context on recall under varying degrees of learning in an attempt to add further interpretation to the findings of Pan. Lists of 25 pairs of words were presented visually to the 20 subjects either 3, 6, 9, or 14 times at one sitting. No recall was attempted until twenty-four hours later. No relation was found to exist between the number of trials and the strength of the association between the words and their contexts. Smith and Guthrie (15) report an unpublished experiment on the effect of a change in the sensory situation on recall by W. R. Wilson. A saving of 11.4 percent in repetitions was effected when the relearning of the nonsense syllables was attempted in the same environment—outdoors or in the laboratory—in which it was learned. It was found that 9.4 percent in repetitions was saved when the odor of peppermint present at the learning was also present during the relearning. Ten subjects participated; lists of 10 nonsense syllables were used as memory material.

In the field of animal behavior the work of many experi-

menters is à propos. The attempts to isolate the various sensory cues employed by animals in learning have established the importance of the total sensory environment in causing the smooth functioning of the act. Watson (16), while demonstrating the value of kinæsthetic cues in the maze problem with the white rat, observed that a change in the maze environment brought about by rotating the maze resulted in a disturbance of the habit. Experiments on rotation of the maze by Porter (14) with sparrows; by Hunter (7) with pigeons; and by Yoakum (18) with squirrels, show that the maze habits of each of these groups are dependent to some extent on the sensory setting in which the learning takes place.

Carr (2) in a series of systematic studies with normal, blind, and anosmic rats describes the influence of changes in various conditions operating at the time of learning. For example, changing the position of the experimenter; covering or uncovering the maze after it had been learned; changing the amount of illumination; altering the space relations of the environment by rotating the maze: all had a detrimental effect on the maze habit. The conclusion is drawn, therefore, (p. 271) that "the sensori-motor act cannot be regarded as an isolated, independent function; the act was learned within a wider sensory environment and it never ceases to be wholly free from these conditions." To this extent, "the stability of the environment furthers the development of the act and conditions the regularity and accuracy of its functioning after it has become automatic."

Patrick and Anderson (13) support Carr's conclusions in their study of incidental stimuli and maze learning. Two groups of rats were used in this experiment. One group learned under changing conditions, with certain incidental stimuli, *e.g.*, the position of the experimenter, the location of lights and shadows and the direction of an auditory stimulus, varying from trial to trial. The second group was confronted with a constant, unchanging situation in respect to these stimuli until learning had been effected. A shift of the incidental stimuli subsequently in a recall test produced no dis-

integrative effects on the response of the first group while the group which had become accustomed to the constant conditions was markedly disturbed, in terms of the time and error scores. The writers conclude (p. 306) that "the white rat learns not the maze pattern alone, as such, but this pattern as it is related to the other stimuli acting constantly along with the maze pattern at the time."

Gengerelli (5) studied the effect of maze rotation on the performance of hooded rats. He observed that no deleterious effects were apparent in terms of the time score of the animals. Results with two types of mazes revealed the same trend of the data. We venture the suggestion, however, that the extreme simplicity of the mazes and overlearning were the influential factors in producing the negative results. It should be noted that 30 and 35 preliminary trials were allowed with the two mazes, respectively.

PART I. CHANGE OF POSTURAL CONDITIONS

In the first experiment an attempt was made to contrast the familiar, habitual situation of being comfortably seated before a study table, with a less familiar, more awkward, standing posture. The supposition was that a change of posture would be detrimental to recall, regardless of the advantages which might accrue to the one or the other as a condition of learning. Half of the subjects learning while seated were seated for the recall test; the other half stood for the recall. Half of those standing during learning stood for the recall test; the others were seated during recall. The different conditions under which learning and recall took place are set forth in the following outline:

Experiment I.—Change of postural conditions, in which the subject is,

- a. seated during learning; seated during recall;
- b. seated during learning; standing during recall;
- c. standing during learning; standing during recall;
- d. standing during learning; seated during recall.

The material memorized by these subjects consisted of lists of 16 short, unrelated, meaningful words which were

presented in serial order until each could be anticipated immediately upon presentation of the preceding word. Five lists were used in rotation with each of the four groups. The words were put together in such a way that adjacent words did not contain the same letters. Words built around each of five vowels were used an equal number of times in each list. Quarter-inch, black gummed letters formed the words in the center of uniform, white 4" by 6" cards. During learning the cards were stacked against a light wooden rack made for the purpose and turned by the experimenter at the rate of one every three seconds. Recall was attempted on alternate presentations to the point of one perfect recitation, *i.e.*, until each word could be anticipated accurately within the three seconds. A stop-watch was used in timing the presentations. The cards were presented only once at the recall test twenty-four hours later and the number of words correctly anticipated during this presentation constituted the recall score. The number of trials required and the words given correctly—both during the learning and at the delayed recall test—were recorded for each subject.

This experiment was conducted at Southern Methodist University during the school year 1929-30 over a period of about two months. The subjects were drawn from the classes in the Department of Philosophy and Psychology at that institution. Learning scores were obtained from 90 students; complete records—of learning and recall after the interval—were procured from 78 of these. The writer served as experimenter.

Each subject upon beginning the experiment was provided with typewritten instructions. When he had read them over he was seated in what was designed to be a natural, comfortable position before a table, in the typical attitude of study (Groups Ia and Ib) while the lists of words were presented to him. In assuming the posture at the table the subject was asked to sit squarely before the table, resting his arms on its surface. If standing, he was told to stand as though he were going to deliver a formal address, with arms by his side and feet together. From time to time throughout the test he was

reminded to stand (or sit) 'just as you were at first,' but after every fifth trial he was allowed to relax in his chair or to sit down, if he had been standing, for a rest period of one minute. This precaution against fatigue was taken when it became evident that otherwise many subjects would be standing or at attention almost an hour at a time in learning the words. Nothing was said, of course, about a possible change of position for the recall test twenty-four hours later and as the four groups involving posture changes were filled simultaneously, the possibility of anticipating the nature of the change was precluded to some extent, at least.

The results of the first experiment are given in Table I. The average number of trials required for the learning and the average number of words correctly anticipated at the delayed recall test are given. The scores of the 78 students completing both parts of the test form the basis of the calculations.

TABLE I
MEANS AND σ 's OF LEARNING AND RECALL SCORES FOR FOUR POSTURAL CONDITIONS

Condition (learning)	No.	Mean (trials)	σ (dis.)	Condition (recall)	Mean (words)	σ (dis.)
a. Seated.....	20	14.95	6.136	Seated.....	12.55	2.037
b. Seated.....	16	16.88	6.254	Standing.....	12.50	2.093
c. Standing.....	20	16.45	7.845	Standing.....	12.75	2.278
d. Standing.....	22	17.50	8.569	Seated.....	12.55	2.610

These figures indicate that the differences in recall scores under the four types of postural conditions are quite small; a computation of the standard error of the differences showed that they are unreliable. We must conclude, therefore, that a change in the posture of the learner did not affect his recall score.

Since these findings were at variance with our expectations, based on the results of some preliminary tests, we have sought an explanation in terms of the conditions under which the present tests were given. Three interpretations seem plausible: (1) It is conceivable that in spite of precautions the tests caused some discussion among the prospective subjects and hence some pre-adjustment to the changed conditions of the experiment. To what extent the forewarned were the fore-

armed is a matter of speculation. (2) The difficulty of the material may have been a factor. The fact that 20 words were used in the preliminary tests instead of 16 leads us to this hypothesis. The failure of Wong and Brown, *opus cite*, to obtain positive results with simpler mental problems lends further support to this supposition. (3) It seems possible that in specifying the postures too rigidly, the 'easy, natural' posture desired was not obtained; and that instead of contrasting an habitual with a novel situation we were dealing with two more or less novel conditions of tension. Therefore, while the posture was changed, the configuration or total situation confronting the subject remained the same. We regard this suggestion as the most likely.

There is some evidence of a difference in the number of trials required to learn the words under the two postural conditions. The difference between the means and the reliability of the difference in terms of its standard error are given in Table II.

TABLE II

MEANS, DIFFERENCE AND RELIABILITY OF DIFFERENCE BETWEEN LEARNING SCORES
OF TWO GROUPS: SEATED AND STANDING

Condition	No.	Mean (trials)	σ (dis.)	σ (av.)	σ (diff.)	D/σ (diff.)
Seated.....	43	15.535	5.266	.803		
Standing.....	47	17.021	8.042	1.173	1.421	1.046
	$(D = 1.486)$					

The seated posture was, therefore, slightly more favorable to learning than the standing.

PART II. CHANGE OF SENSORY MODE OF PRESENTING THE STIMULUS WORDS

In the second experiment the variable factor was the method of presenting the material to be memorized. The different conditions under which learning and recall took place are set forth in the following outline:

Experiment II.—Change of sensory mode of presenting the stimulus words, in which there is,

- a.* visual presentation during learning; visual at recall;
- b.* visual presentation during learning; auditory at recall;
- c.* auditory presentation at learning; auditory at recall;
- d.* auditory presentation at learning; visual at recall.

Thus, half of the subjects received the material visually, and half, auditorially, during the learning period. Half of them recalled the words under the condition prevailing at learning (Groups *IIa* and *IIc*) while the other half (Groups *IIf* and *IId*) recalled under changed conditions so far as the method of stimulation was concerned.

The conditions of this experiment necessitated a change in the memory material. Consequently, lists of 10 paired associates were constructed, each pair being made up of a short meaningful word and a nonsense syllable. During learning the first word of the pair was always presented simultaneously with the nonsense syllable, visually or auditorially. In recall tests the stimulus word was shown or spoken and the nonsense syllable was spelled out, orally. Five lists of the paired associates were used in rotation with each of the four groups.

The material here, too, was presented by means of 4" by 6" cards, the words or syllables being typed in the center of the cards. Three packs of cards were used in these tests: one, in which the two words of the pair were typed for visual presentation during learning; one, in which only the stimulus words appeared, for testing recall with visual presentation of the stimulus; and one in which only the nonsense syllable (response word) appeared, for use during the learning period when the stimulus item was presented auditorially. During the learning of the material and when needed in the recall test (visual presentation) the cards were propped in front of the subject by means of the afore-mentioned rack and turned by the experimenter at the rate of one every three seconds. At the outset of the learning period the pairs were presented twice before recall was attempted; thereafter, a recall test was made after every presentation of the list. The serial order of the pairs was kept constant during presentation for learning but the experimenter was careful to shuffle the stimulus items each time before testing recall. In this way

the words of the pair were associated with each other and not merely with a certain position in the series. Learning was prolonged to the point of one perfect recitation and accomplishment was measured in terms of the number of trials required. At the recall test twenty-four hours later the stimulus words were presented only once and the recall score was the number of syllables spelled out correctly within the allotted time.

The tests in this experiment were completed by 119 subjects. Fifty-six students in the Department of Philosophy and Psychology at Southern Methodist University comprise Groups IIa and IIb. Groups IIc and IId were made up of 36 students from the latter University and 27 from the University of Chicago (Summer Term, 1930), the students of the two schools being divided almost equally between the two groups.

Typewritten instructions were furnished the subjects at

TABLE III

MEANS AND σ 's OF LEARNING AND RECALL SCORES IN GROUPS REPRESENTING CHANGES IN MODE OF STIMULATION

Condition (learning)	No.	Mean	σ (dis.)	Condition (recall)	Mean	σ (dis.)
1. (S. M. U. Subjects)						
a. Visual.....	28	11.18	5.289	Visual.....	7.50	1.476
b. Visual.....	28	11.46	5.660	Auditory.....	6.71	1.411
2. (S. M. U. Subjects)						
c. Auditory.....	18	9.22	3.661	Auditory.....	8.06	1.308
d. Auditory.....	18	7.72	3.870	Visual.....	6.50	2.114
3. (Chicago Subjects)						
e. Auditory.....	14	10.64	4.966	Auditory.....	7.50	1.998
d. Auditory.....	13	12.23	7.433	Visual.....	7.08	1.857
4. (S. M. U. and Chicago Subjects—Combined Scores of Sections 2 and 3)						
e. Auditory.....	32	9.84	4.573	Auditory.....	7.81	1.664
d. Auditory.....	31	9.61	6.246	Visual.....	6.74	2.032

the beginning of each test. In Groups II*c* and II*d* the subject was told to get the word that he heard connected with the syllable that he saw. The response word only was then shown while the meaningful, stimulus word was spoken by the experimenter simultaneously with the turning of the card.

The accomplishment of each of these groups in terms of mean scores in learning and recall is shown in Table III.

On the basis of these figures we conclude that the change in method of presenting the stimulus words was detrimental to recall both when the measurements were made with Texas and with Chicago students as subjects. In considering the performance of all subjects in the four groups we find that 7.9 percent fewer words were recalled when visual presentation was changed to auditory at the time of recall; 10.7 percent fewer, when auditory presentation was changed to visual.

The differences in mean recall scores and the reliability of these differences are given in Table IV. The differences are quite significant in terms of our standard of reliability.

TABLE IV

DIFFERENCES AND RELIABILITY OF DIFFERENCES IN RECALL SCORES IN GROUPS REPRESENTING CHANGES IN MODE OF STIMULATION

Condition (recall)	Diff. in Means	σ (av.)	σ (diff.)	D/σ (diff.)
a. Visual.....	.79	.279	.386	2.036
b. Auditory.....		.267		
c. Auditory.....	1.07	.294	.469	2.284
d. Visual.....		.365		

The median recall scores for the four groups of subjects are given in Table V. They, too, are higher when the conditions are kept constant.

The influence of the changed conditions is further observed in a study of the differences in the distribution of scores under the two conditions. Table VI affords the comparison.

It is evident that the larger percentage of high scores occurs in the groups working under constant conditions of recall. Thus, 28.56 percent of the 'visual to visual' group missed no more than one of the ten words; only 10.71 percent of the

TABLE V
MEDIAN RECALL SCORES IN GROUPS REPRESENTING CHANGES IN METHOD OF
PRESENTATION OF STIMULUS

Condition	No.	Median
a. Visual to visual.....	28	8.00
b. Visual to auditory.....	28	7.00
c. Auditory to auditory.....	32	8.63
d. Auditory to visual.....	31	7.31

'visual to auditory' group did as well. Approximately 41. percent of the 'auditory to auditory' group recalled as many as nine of the words; 22.61 percent of the 'auditory to visual' group achieved that score.

Some evidence of a difference in the efficacy of the two sensory methods of presenting stimuli is offered in a comparison of the learning scores under the two conditions. Only

TABLE VI
DISTRIBUTION OF RECALL SCORES UNDER CONSTANT AND CHANGED CONDITIONS OF
STIMULATION

Constant Conditions (visual to visual)			Changed Conditions (visual to auditory)		
Recall	No.	Percent of Group	Recall	No.	Percent of Group
4	1	3.57	4	2	7.14
5	2	7.14	5	2	7.14
6	3	10.71	6	10	35.70
7	8	28.56	7	6	21.42
8	6	21.42	8	5	17.85
9	6	21.42	9	2	7.14
10	2	7.14	10	1	3.57
	28	99.96		28	99.96
(auditory to auditory)			(auditory to visual)		
1	0	—	1	1	3.23
2	0	—	2	0	—
3	1	3.13	3	0	—
4	0	—	4	3	9.69
5	3	9.39	5	4	12.92
6	2	6.26	6	5	16.15
7	5	15.65	7	8	25.84
8	8	25.00	8	3	9.69
9	9	28.17	9	4	12.92
10	4	12.52	10	3	9.69
	32	100.12		31	100.13

the scores of the Southern Methodist students are discussed in the comparison of methods. Table VII gives the average scores of 85 students receiving the material visually while responding orally (Groups IIa, IIb, and IIIb, to be described later in connection with the next experiment) compared with those of the 36 S. M. U. students receiving the material auditorially (while responding orally) in the learning period.

TABLE VII

DIFFERENCES AND RELIABILITY OF DIFFERENCES IN LEARNING SCORES WITH VISUAL AND WITH AUDITORY PRESENTATION

Condition	No.	Mean	σ (dis.)	σ (av.)
Visual stimulation.....	85	11.094	5.986	.649
Auditory stimulation.....	36	8.472	3.841	.640
	Diff. = 2.622		$\sigma(\text{diff.})$ D/σ (diff.)	= .912. = 2.876

The auditory method is shown to be decidedly the better so far as the Texas students are concerned. These results are in accord with the findings of certain experimenters, Henmon (6) for one, while not entirely in agreement with others. Koch (8) for example, finds the auditory method uniformly inferior to the visual or visual-auditory combination methods but we believe that the differences in technique may account for the discrepancy in results.

The set-up of our experiment in which a study of recall was the primary objective does not afford an authoritative interpretation of the relatively poor learning scores of the Chicago group—all of whom worked under conditions of auditory stimulation. The establishment of a reliable difference between the students of the two schools would presumably lend support to the contention of certain other writers, notably Carr (3) p. 230, that the superiority of either method must be explained partly, at least, in terms of differences in past training and interests of the subjects. We assume, in accepting this explanation, that the lecture method (auditory presentation of material) is typical of the undergraduate courses while the library method (visual presentation) characterizes the graduate work.

PART III. CHANGE IN THE FORM OF THE RESPONSE AT THE TIME OF RECALL

The third of our experiments was concerned with changes in the form of the response at the recall test. The different conditions of learning and recall are given in the following outline:

Experiment III.—Change in form of response during recall, in which there is,

- a. oral response during learning; oral recall;
- b. oral response during learning; written recall;
- c. written response during learning; written recall;
- d. written response during learning; oral recall.

The lists of paired associates employed in the second experiment were used here. The instructions were modified slightly to make them suitable for Groups IIIc and III d. It may be seen that Group IIIa is identical with Group IIa both as to conditions and as to subjects participating. It represents a control group in which the conditions of stimulation (visual) and the conditions of response (oral) remained constant for the recall tests. In the learning tests of Groups IIIc and III d, and in the delayed recall tests of IIIb and IIIc, the subjects were provided with cards on which spaces numbered from 1 to 10 were arranged. The subjects wrote the response syllables on these cards whenever recall was to be tested other than orally. It should be noted that both in the immediate and in the delayed recall tests subjects were asked to cover the words as they wrote them. In this way the situation was made more analogous to the one obtaining when the response was oral.

Two presentations were allowed, as formerly, before recall was tested; thereafter, recitation alternated with presentation of the series during the learning period.

Groups IIIa and IIIb, 28 and 29 subjects, respectively, were tested at Southern Methodist University; Groups IIIc and III d, 24 and 26 subjects, respectively, were tested at the University of Chicago. One-hundred-seven complete records are thus involved in this experiment, including the 28 duplicates of IIIa.

The results of this experiment in terms of mean scores appear in Table VIII. It may be observed that the scores of the four groups are almost identical, showing no effect of the conditions imposed.

TABLE VIII

MEANS AND σ 'S OF LEARNING AND RECALL SCORES IN GROUPS REPRESENTING CHANGES IN THE FORM OF RESPONSE

Condition (learning)	No.	Mean	σ (dis.)	Condition (recall)	Mean	σ (dis.)
a. Oral response.....	28	11.18	5.289	Oral response....	7.50	1.476
b. Oral response.....	29	10.66	6.834	Writ. response...	7.28	1.556
c. Written.....	26	10.27	5.842	Written.....	7.31	2.088
d. Written.....	24	10.13	4.936	Oral.....	7.50	1.682

A computation of the standard errors revealed no significant differences between the four groups. However, the distribution of scores, given in Table IX, affords evidence

TABLE IX

DISTRIBUTION OF RECALL SCORES UNDER CONSTANT AND CHANGED CONDITIONS AS TO THE FORM OF THE RESPONSE AT RECALL

Constant Conditions (oral to oral)			Changed Conditions (oral to written)		
Recall	No.	Percent of Group	Recall	No.	Percent of Group
3	0	—	3	1	3.45
4	1	3.57	4	1	3.45
5	2	7.14	5	2	6.90
6	3	10.71	6	3	10.35
7	8	28.56	7	5	17.25
8	6	21.42	8	14	48.30
9	6	21.42	9	1	3.45
10	2	7.14	10	2	6.90
	28	99.96		29	100.05
(written to written)			(written to oral)		
4	4	15.40	4	2	8.34
5	3	11.55	5	2	8.34
6	3	11.55	6	2	8.34
7	2	7.70	7	3	12.51
8	2	7.70	8	8	33.33
9	9	34.64	9	5	20.85
10	3	11.55	10	2	8.34
	26	100.09		24	100.04

unfavorable to the changed conditions. Almost 29 percent of the group articulating the words both at learning and at recall remembered 9 or 10 of the ten words; 10.35 percent of the 'oral to written' group did as well. Approximately 46 percent of the group writing the words in the learning and in the recall tests scored 9 or 10 in the recall test; only 29 percent of the 'written to oral' group did as well. We observe from this that many subjects were disturbed by the changed conditions of response even though the average performance remained practically the same under the two conditions.

SUMMARY

Three conclusions have been formulated with reference to the learning experiments of this study: (1) Learning scores—the number of repetitions required for one perfect recitation—are affected, on the average, by the posture assumed at the time of learning, a slight tendency in favor of the seated posture being evident. (2) Learning scores are a function to some extent, of the sensory mode of presenting the Stimulus series, the auditory method being preferable in the group in which the comparison was possible. (3) Learning scores are independent of the form of the response used in apprehending the material, writing the responses in the practice period having no advantage over speaking them in fixing the associations.

The main results are concerned with the topic of recall, and the following facts are offered as the outcome of the tests of retention: (1) Recall scores—the number of correct responses after an interval of twenty-four hours—are unaffected by a shift in the kinæsthetic situation as produced by the assumption of a different posture at the recall test. Changes in the stimulating situation are ineffectual to this extent in breaking up the recently established associative sequences. (2) Recall scores are lowered and the number of high and perfect scores markedly decreased by a change in the sensory mode of presenting the stimulus words at the recall test. (3) Recall scores are unaffected by a change in the form of the response demanded at the time of the recall test. The number of high scores is reduced with changed conditions but on the

whole it appears that a response once learned can be executed in either the written or oral form with no loss in accuracy.

The theoretical significance of these results lies in their bearing on certain topics widely discussed in the literature of the present day. Many writers, both Gestalt and non-Gestalt, are insisting on the importance of the total stimulating situation in determining the response. We believe our results to be in essential harmony with this doctrine while demonstrating a certain amount of independence in the specific stimulus-response connections. We interpret the failure of the conditions of Experiments I and III to produce marked effects on recall as evidence against a point-for-point connection in the sensory-motor system and at the same time, as evidence which brings out the value of the complete stimulus pattern in determining the response. It has been suggested that learning under both the postural conditions of our experiment was a reaction to a novel, unnatural situation, and that a shift of these conditions at the time of recall was ineffectual, therefore, to the extent that a new situation was not created thereby. In the same way, the request to write or to speak the associated sequence of words produced no conflicting tendencies. On the other hand, a shift in the mode of stimulation produced a real situational difference for the subjects as evidenced by their distinctive learning activity under the two conditions. The response at the time of recall was disrupted accordingly with a real change in the situation.

From the third experiment it appears that we have derived results with human subjects which are in general conformity with Lashley's theory of the equivalence of motor responses. In spite of certain individual differences it appears that the mode of responding can be changed within certain limits with no effect on the speed and smoothness of the induced response. Whether this ready shift from one form to the other is a function of native neural propensities, as suggested by Lashley (10) in his experiments on bilateral transfer in the animals of his studies, or whether it is the result of an acquired agility is a matter of individual interpretation. It seems highly probable, however, that our results are a

function partially, at least, of the highly trained college students serving as subjects in our experiments. It is conceivable that such dexterity might not have been demonstrated with elementary school children in the role of subjects or with others in whom the writing and talking responses were less highly automatized at the time of the experiment.

Equivalence of sensory stimuli, in Lashley's terminology (9) is clearly not demonstrated in the present study. It appears that auditory stimuli cannot be substituted for visual stimuli without a loss in effectiveness. It has been suggested that this lack of transposability may well be a function of the differences in training and habits of study of the individual subjects, however. It is possible, therefore, to regard this as a case where the native propensities of the sensory pathways have been modified again through the individual's experience, bringing with it this time a loss in the effectiveness of one of the sensory modes.

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